APPLICATION OF AERIAL PHOTOGRAPHY TO THE ECONOMIC ANALYSIS OF LAND-USE FOR URBAN PLANNING

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ABSTRACT

This report presents an item-by-item tabulation, for the major components of Urban Analysis, of the uses and limitations of aerial photography. It describes the application of techniques for urban land study in the sequence of inventory, analysis and plan. Its development should provide a guide to city and county administrators and photogrammetric engineers alike in planning surveys based on aerial photography and should encourage the more extensive use of aerial survey methods in day-to-day administration.

This report considers techniques for analysing the dynamic economic forces of urban growth and change which underlie engineering considerations in urban land-use. The dynamics of growth and directions for future development can thereby be systematically studied to provide reasonable predictions of future urban growth and future land-use requirements. These techniques have been developed as part of a continuing investigation into methods for using aerial photography to supply data on land-use for urban planning and real estate development.

The great advantage in using aerial photography lies in its capability for providing the analyst with a powerful tool which is at once an overall perspective of the city, a historical record of its growth, a means for comparative analysis of various uses of the land, and also a means for statistical data not otherwise available for any area he wishes to consider.

Techniques for extracting useful statistical data about the urban area from aerial photography are based on delineating various sections of the city according to functional use of the land, the structural arrangement of buildings, and built-up area density and then determining the mathematical relationships among these features.

Over the past 10 years the author has presented reports on a continuing investigation on systematic methodology for applying aerial photography to various problems in urban planning. These and similar techniques have now become widely accepted and find application in all phases of urban planning related to zoning, utility service areas, trade areas, civil defense, subdivision layout, industrial location, traffic flow and other administrative activities. Data of this type have been especially useful in real estate development.

To determine the applicability of various methods for urban analysis, a small town was selected as a test area in which various problems could be readily isolated and studied over a period of several years.

The area selected for testing was the city of Rockville, Md. a typical small town caught up in the rapid suburban expansion of a large metropolitan area. The town exhibited all the basic problems of administration and planning engendered by rapid growth, traffic congestion, inadequate facilities, small staff, and above all, lack of adequate data to meet the changing events. In the seven years since this town has now been studied, the population has grown from 13,000 to almost 30,000 at the beginning of 1961. In 1953 the town was thinking mainly in terms of its traditional role as the county seat of a rural county. Since then new elements, largely urbanites from Washington seeking a suburban way of life and interested in enhancing the local community, have become the moving force in its development.

The first report in this investigation[1/] discussed the basic methodological concepts of Photo Sociometrics, a measurement technique for the study of land-use in aerial photography.

These techniques are predicated on the concept that urban patterns are the physical manifestations of complex cultural and economic events, as well as the result of specific adjustments to climate and terrain.

1/ Photogrammetric Engineering - Volume 20, Number 3, page 419, 1954.

The study of land-use therefore consists of organizing the physical features of each area of the city into distinct patterns which are readily determined in aerial photography. These are the patterns of function, structure type and density of roof cover.

The function pattern represents the major land-use categories, such as industrial, commercial, governmental, institutional, recreation, port, railway, or residential.

The structure-type pattern, consists of the categories of warehouses, storage yards, factories, commercial buildings, schools, churches, and various residential apartment, row, and single dwellings.

The density of roof coverage pattern indicates the arrangement, organization and limits of dense, moderate, and sparsely built-up areas.

The characteristics of each area are easily determined from aerial photography because specific types of construction are required for each function. Types of construction in industrial, port, or railway areas reflect the needs and capacity of the industrial production or of the transport media. Types of construction in residential areas reflect the ability of different classes of people to command various categories of housing and living space.

The three forms of distribution bear the following relationship to each other. Function is the major component, which is subdivided into its structure-types, in turn these are modified by degree of density of roof cover.

Ground sampling of small areas within each area supported by documentary information supplies the basic data, by which the spacial extent of area, measured in air photos provides useful urban data.

These techniques were also tested on cities outside of the United States in areas where the pattern of urban development had an entirely different utilization of urban land.

A report published in the International Archives of Photogrammetry[2] describes the analysis of a city in India where two different cultures in juxtaposition for a long period of time could be studied. The specific problem selected was to determine water requirements

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[2] International Archives of Photogrammetry, Proceedings of the 7th International Congress of Photogrammetry, Washington, September 1952 - Volume 11, Part 3, page 710, 1954.

from the patterns of land-use in the city of Kanpur. The various residential, industrial and other functional areas of the city were identified and delineated in aerial photographs and their extent transplated into amount of population, or size of industrial plant. Such data could be used to estimate requirements for water facilities.

The second report on Rockville[3] covered the development of photo techniques to aid detailed ground sampling of small areas. This sampling in turn provided the air photo study criteria for city-wide and county-wide evaluations via aerial photography. The method was applied to the consideration of availability of vehicles for evacuation of home population in event of civil defense emergency and also to various patterns of movement under changing conditions of possible radio-active fallout. These data were developed by traffic drainage sheds for which the air photo was used to relate dwellings and vehicles to means of egress.

The third report on Rockville[4] detailed the general application of photosociometrics to the study of land-use in a systematic sequence of (1) land inventory, (2) analysis and (3) plan, and is presented here briefly because the methodology is basic in urban planning.

Only slightly additional cost is entailed in projecting the use of aerial photography from mapping to analysis and planning.

In each of three main aspects of urban study indicated in Figure 1 the application of aerial survey permits:

Inventory--A complete inventory of the physical features of the urban area; the topography of its site and surrounding area, the drainage pattern, built-up and open areas, the road pattern and other means of communication, and the location and identification of individual installations.

Analysis--The classification of the features of the urban area as land-use patterns of function, structure-type, and built-up area density, so as to characterize the population distribution, industry, commerce, community services and facilities, and the movement of people and goods.

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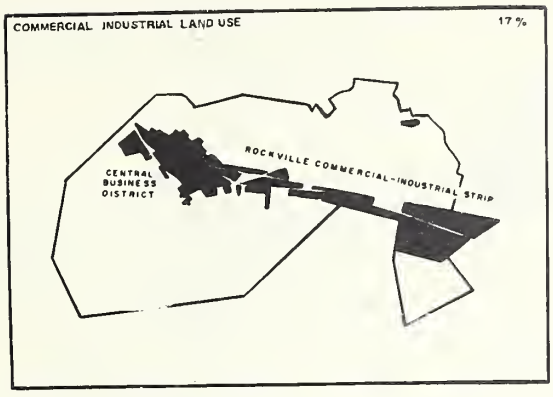
[3] Photogrammetric Engineering - Volume 21, Number 4, page 566, 1955.

[4] Photogrammetric Engineering - Volume 22, Number 4, page 656, 1956.

Commercial-Industrial Land-Use



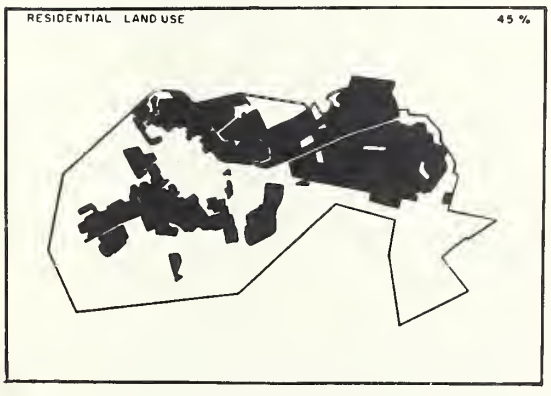
DATA OBTAINED

* Location and classification of all commercial industrial, parking, non-conforming and vacant areas zoned commercial-industrial.
* Measurement of size of commercial and industrial floor areas, parking lot spaces, and vacant space.
* Ratios of:
  Zoned commercial/ Total urban area
  Occupied and Vacant/ Zoned
  Parking/ commercial

APPLICATION AND ACCURACY

* Supplied basic statistics well within required accuracy for planning of zoning changes, acquisition of parking lots, street improvement.
* Ground-check was required to locate non-conforming dwellings used for commercial. This class comprised less than 4% of area.

Residential Land-Use



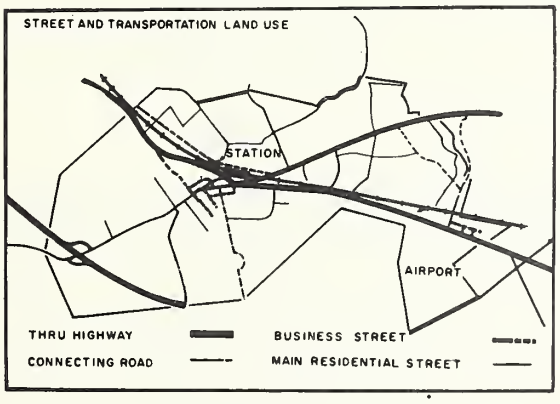
DATA OBTAINED

* Location and classification of all residential areas by density, structure-type, and lot size.
* Measurement of zoned areas occupied, number and type of dwellings, floor area per dwelling and percent of zoned area built up.
* Computation of population by dwelling type and area.

APPLICATION AND ACCURACY

* Accuracy of dwelling count, size and type of lot within 2% of ground checked sample area.
* Basis for changes in zoning, acquisition of school and recreation sites, trade areas, utility requirements, tax assessment among many others.

Streets and Transportation Land-Use



DATA OBTAINED

* Location and classification of all streets by use as through highways, primary and secondary connecting roads, business and residential streets.
* Location and classification of railroad, bus, and airport facilities.
* Measurement of streets by total length, width and use type.
* Traffic potential according to adjacent land-use, pattern of streets, and number of dwellings, served by each street.

APPLICATION AND ACCURACY

* Data used for right of way acquisition street improvement, traffic flow analysis. Adequacy of railroad facilities equated to needs for proposed commuter railroad traffic.
* Use classification based on photo study of surrounding land use and general familiarity with the area.
* Street dimensions and mileage within 2% of city engineer's ground survey.

Figure 1

Aerial Photography Applied to Urban Land-Use Inventory.

(continued to page 6)

Recreational and Other Developed Open Land-Use

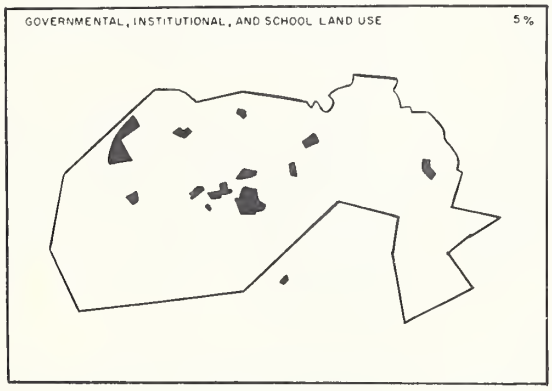
DATA OBTAINED

* Location and classification of all parks, golf clubs, and cemeteries.
* Measurement of area occupied, number type and capacity of buildings and other outdoor facilities.
* Ratios of available facilities to requirements per thousand inhabitants.

APPLICATION AND ACCURACY

* Basis for zoning changes, acquisition of new parks and facilities to meet needs of growing population.
* Data well within range of accuracy required for planning.

Governmental, Institutional and School Land-Use



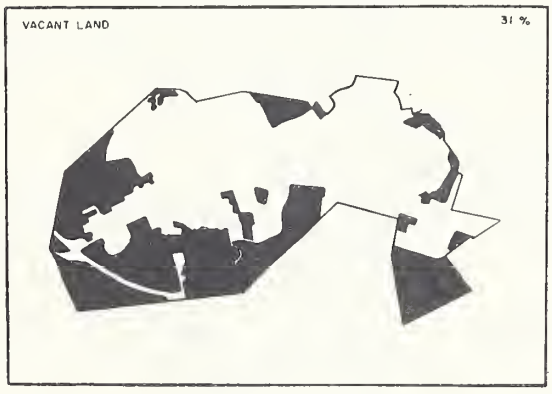
DATA OBTAINED

* Location and classification by type and area.
* Measurement of land occupied, number and type of structures and outdoor facilities.

APPLICATION AND ACCURACY

* Basis for school district planning particularly for new subdivisions.
* Ground check to determine denominations of churches, purpose of institutions and indoor facilities.

Vacant Land (Unzoned)



DATA OBTAINED

* Location and classification of farm, fallow and wooded areas.
* Measurement of size: description of terrain in each area.

APPLICATION AND ACCURACY

* Basis for planning new zoned areas.
* Measurements well within required accuracy for planning.

Figure 1 (continued)
Aerial Photography Applied to Urban Land-Use Inventory.
(continued to page 6)

Planning--The relating of engineering standards to land-use features, in order to plan the size, capacity and location of facilities, and to estimate the amount of work entailed in preparation of site.

INVENTORY

Inventory is the first step in land-use study. It permits a town to take stock of its resources and to gain an over-all appreciation of its problems.

From the air photo, data are assembled area-wise, by delineation of the built-up area, road system, functional areas, structure-types and vacant land. These are classified by number and type, and assembled as patterns which characterize the distribution of population, commerce and industry, community facilities and means for movement of people and goods.

Three principal categories of information are considered in the inventory:

1. Location and Classification of all features, as distribution patterns.

2. Measurement of size and capacity, to develop basic statistical data assemblies.

3. Computation of ratios of land use and land zoned, service availability and facility accessibility to residential, commercial and industrial needs.

Beyond meeting the need for over-all planning data, the air photo has surprising accuracy and capability for developing detailed statistical data. Figure 1 presents a series of panels which summarize for each land use category, the scope, applicability, and accuracy of inventory data obtained from aerial photography with some ground check.

ANALYSIS

Analysis is made by combining the inventoried data (such as number of inhabitants per dwelling unit obtained by ground sampling, number of cars per dwelling unit, daily water use per capita), with planning multiplier factors such as road capacity per thousand vehicles, school rooms and acres of recreational land per thousand people, commercial floor area per thousand dollars of sales. Detailed ground sampling and constant check of literature improve the accuracy of the multipliers. By this means pertinent data can be assembled for almost any analytic purpose.

With these data a second reading of the air photos is made to locate the reasons for outstanding existing and potential planning problems. As an example of the application of the analytic phase of study, one facet of the land use inventory and its succeeding analytic and planning considerations are illustrated.

The central business district was laid out originally to serve the older western portion of the city-the entire city prior to 1949-but now comprising only one-seventh of the total population. The business community had failed to appreciate how large and rapid the expansion would be in the eastern portion of the city now comprising six-sevenths of the population. Adequate provision was not made for this trade; merchants were content with a modest increase in sales. However even this modest increase resulted in a considerable traffic congestion because roads and parking facilities were inadequate for accommodating this new trade.

Figures 2 and 3 illustrate the problem and the method for solution of central business district traffic problems.

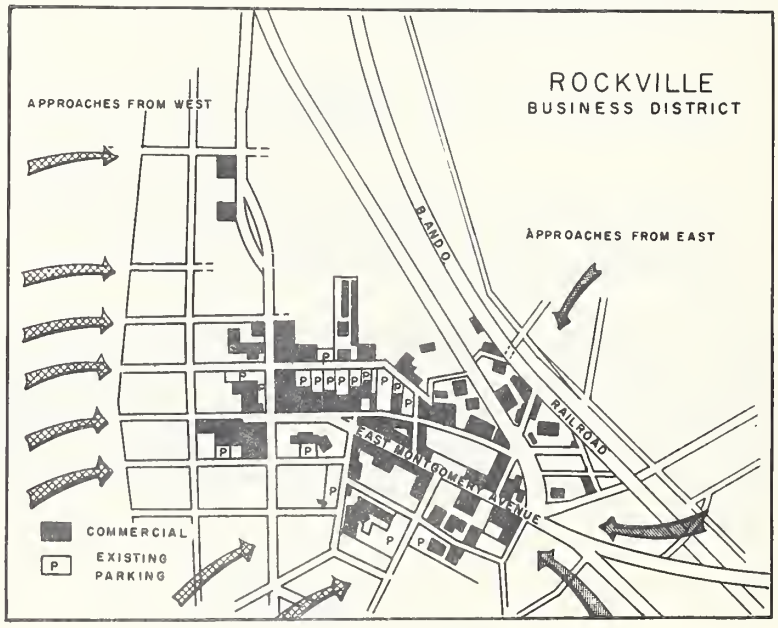


Figure 2

Traffic patterns in central business district. The eight routes of approach to the central business district serve 1/7 of all the families. Two routes of approach from the east serve 6/7 of all the families, as well as heavy through traffic. The majority of this traffic uses the narrow main business street going and coming. The other route from the east serves only a small section of the town.

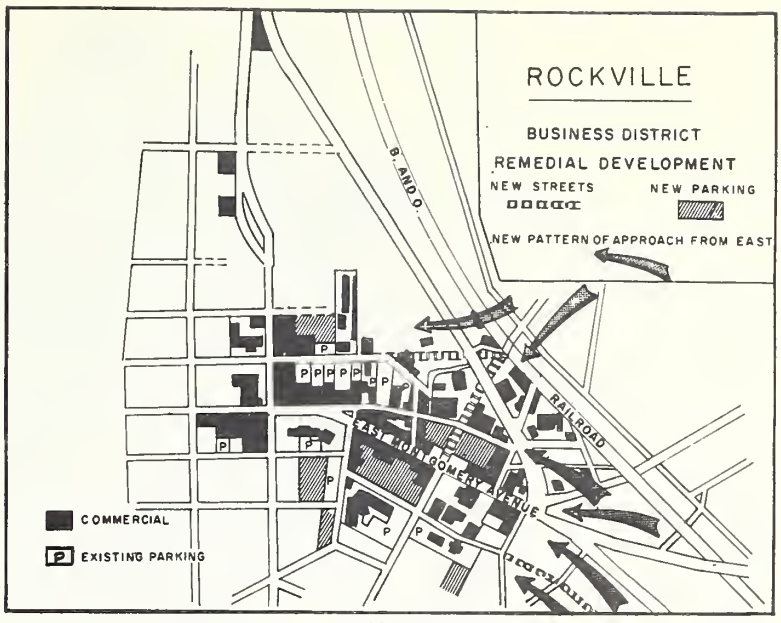


Figure 3

Remedial traffic and parking development. Improvement in traffic circulation is possible by creating new routes of approach and proper placement of new parking lots. The air photos revealed that present parking capacity could be more than doubled by using wasted backyards, alleys and vacant lots in the business district and that new streets could be constructed without dislocating existing occupants. The new pattern of approach from the east would reduce movement on the main street yet provide equal or greater access to shops.

PLANNING

Study of the photos also suggested a program for long range development of a larger and more adequate business district, (Figure 4).

The objective was to take advantage of Rockville's superb central position in the expansion of the surrounding county where new science industry was developing on a large scale because of proximity to the national capital. Whenever the city expands through annexation to the maximum expansion limits proposed in the master plan, there will be 14.1 sq. miles (9,049 acres) within the city, 5.5 sq. miles (3,520 acres) of which will be served by this sanitary sewer system.

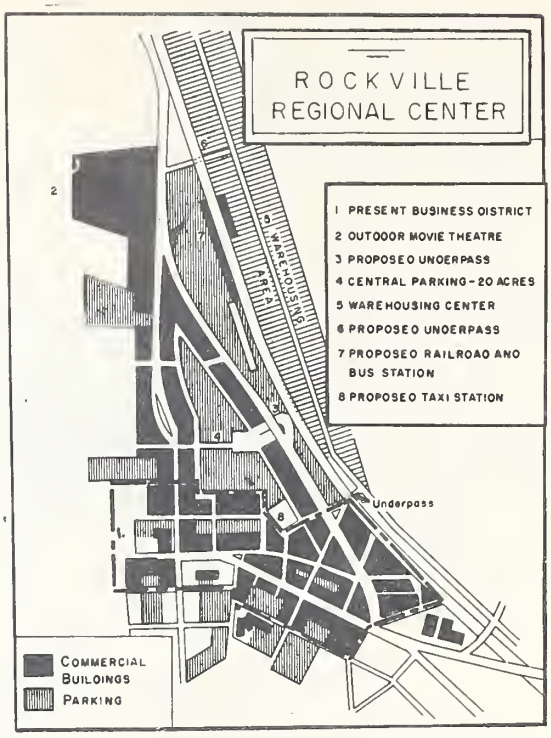


Figure 4

Future growth. Suggested expansion of present business district onto vacant land lying to the north. The large central parking area, underpass approach; and additional parking provided by the computer parking lot adjoining the railroad would provide an attractive center with adequate parking and access routes.

Currently in 1961, the western portion of the city is also growing rapidly, (Figure 5). This is bringing the business district back into a central position once again. A huge new shopping district is under development to take advantage of this new situation, thus generally following the originally suggested plan. One of the new facilities in this center is a huge home furnishing mart, which is a unique facility designed to attract trade to Rockville from a wide surrounding area.

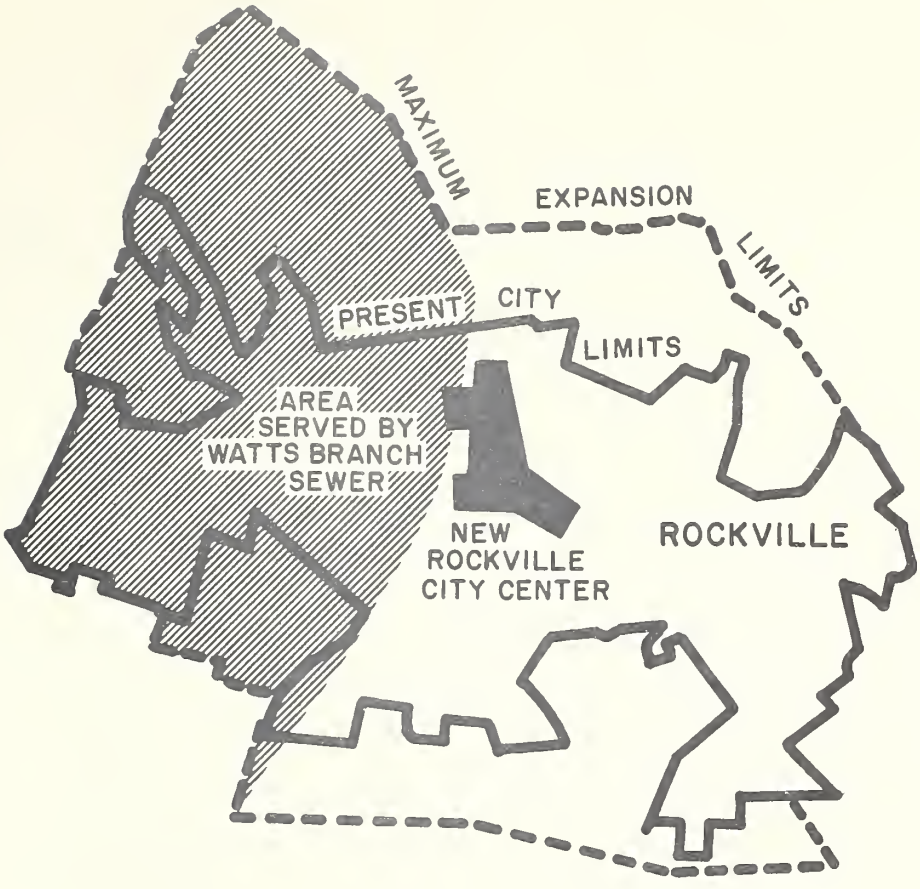


Figure 5

This drawing shows a huge area that was just opened up for development in the western part of the city through completion of the Watts Branch Sewer.

An urban renewal program is also under way to rebuild the older commercial areas so they can be combined with the newer commercial development into one huge new central business district.

The changing situation for the central business district of Rockville from a central to a peripheral position and back to central position within a period of 10 years, points up the necessity for considering the effects of time as a dynamic economic force in the analysis of land-use.

We have learned that land-use planning to have any long term validity must closely consider the complex economic forces which constantly change the utility of various areas of the city.